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Regional Comparisons of the Thickness of Moa Eggshell Fragments (Aves: Dinornithiformes)

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ABSTRACT. Samples of moa eggshell fragments from eight sites throughout New Zealand were measured to investigate the usefulness of the graphed distribution of eggshell-thicknesses in reflecting the moa fauna of the site. Assuming larger moa species laid eggs with thicker eggshells, a frequency histogram of eggshell thicknesses for each site seems to mirror what is known (from bones) of the incidence and relative abundance of large and small moa species at the site. This is particularly so for North Island sites which had lower moa diversity than South Island sites. At North Cape and Tokerau Beach abundant thin eggshell (mode at 0.90–0.94 mm) was probably produced by *Euryapteryx* "*curtus-gravis*" and *Pachyornis geranoides*, and rarer thick eggshell (mostly 1.2–1.7 mm) by *Dinornis novaezealandiae*. At both Puketitiri and Castle Point there were broadly unimodal distributions of thin to medium-thickness eggshell, with thick eggshell almost absent. At Puketitiri the eggshell is assumed to be mainly from *Anomalopteryx didiformis*, and the slightly smaller *P. geranoides*, and averages thicker with a broader range than at Castle Point where the assumed identity of the eggshell lies with two small species (*P. geranoides* and *Eu. "curtus-gravis"*). At the four South Island sites the correlation to species is less clear. The modal thicknesses at Wairau Bar, Oamaru, Chatto Creek and Shag River are all in the range 1.15–1.44 mm and probably largely attributable to *Eu. "curtus-gravis"* which has a large form in the South Island and dominates the bones at all four sites. However, several other moas could have contributed the thinnest and thickest eggshells in most of the South Island samples. Archaeological sites had similar large ranges of eggshell-thickness to natural sites, suggesting that Maoris collected moa eggs from all available species and not just the largest ones. The study demonstrates the usefulness of eggshell-thickness histograms at particular sites as an adjunct to, or surrogate for, information on the relative abundance of moa bones, especially for North Island sites.

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Fossil bones and eggshell fragments are the main evidence of the former presence in New Zealand of moas (Dinornithiformes), the extinct large ratite birds currently thought to number 10 species (nomenclature after Worthy & Holdaway, 2002; Bunce *et al.*, 2003; Worthy, 2005). Moa eggshell fragments are common, often in large quantities, in various archaeological and Holocene fossil sites throughout New Zealand. However, there has been little research on the nature and characteristics of moa eggshell fragments, and reports of archaeological and paleontological excavations typically and unhelpfully record "moa eggshell", without further analysis. One aim of my recent work on moa eggs and eggshell (Gill, 2000, 2006, 2007) has been to seek a better understanding of unassociated, broken moa eggshell.

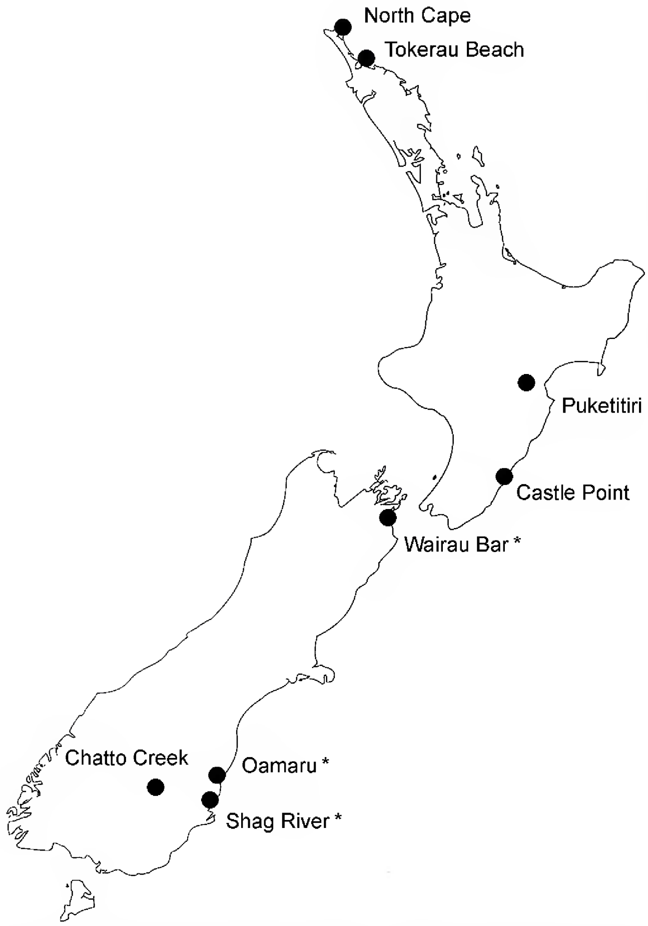


Figure 1. Locality map of New Zealand showing eight sites (four from each of North and South Islands) for which samples of moa eggshell fragments were measured in this study. Archaeological sites are marked with an asterisk (*).

It is well known that moa eggshell fragments vary in thickness, and differences between "thick" eggshell (ca. 1.3–1.7 mm) and "thin" eggshell (ca. 0.5–1.0 mm) were noted earlier (e.g., Archey, 1931). Thicker eggshell fragments presumably derive from larger eggs that were produced by the larger species of moas. Support for this comes from a general positive correlation between the lengths of whole moa eggs and their eggshell thicknesses (Gill, 2007: fig. 5). The moa fauna in a given region is a subset of the known species, and it follows that the thicknesses of the moa eggshell fragments at a fossil site should reflect the sizes, and thus identities, of the resident species of moa. The relative abundance of eggshell of different thicknesses at a site might also reflect the relative abundance of the species that produced them.

The aim of this study was to analyze the thickness of moa eggshell fragments at a range of sites and look for agreement between the thickness profiles and the diversity and relative abundance of the moa species at the sites as determined from bones. It was a test of the notion that a histogram of thicknesses taken from a large sample of eggshell fragments at a site gives a profile reflective of moa composition at the site.

Materials and methods

Sites. I examined samples of moa eggshell fragments at eight sites or geographic areas chosen because they had yielded large samples held in museum collections, and the sites were spread latitudinally throughout New Zealand (Fig. 1). Five are natural sites, known (or assumed) to be of Holocene age, i.e. no older than 10,000 years before present. Three archaeological sites, all in the South Island, are assumed to date from within 100–200 years of first human settlement of New Zealand (which was ca. 1250 A.D.; Anderson, 1991; Wilmshurst *et al.*, 2008). The sites were as follows (see Table 3 for latitudes and sample sizes; see Appendix for museum registration numbers):

- *North Cape, Northland* (natural sites)
- *Tokerau Beach, Northland* (natural sites; same sample analysed in Gill, 2000)
- Puketitiri, Hawke's Bay (natural sites)
- *Castle Point region, Wairarapa Coast* (natural sites)
- *Wairau Bar, Marlborough* (archaeological site)
- *Oamaru, North Otago* (archaeological site)
- *Chatto Creek, Central Otago* (natural sites)
- *Shag River mouth, Otago* (archaeological site)

Samples. Eggshell fragments from the selected sites were examined closely and any with significant signs of surface-wear were rejected. For each acceptable fragment (n = 3565), one measurement of eggshell thickness was made to the nearest 0.01 mm (with vernier callipers or a screw micrometer) at an undamaged point on the edge of the fragment. Thicknesses were plotted as histograms with 0.05 mm intervals to give a very finely-divided spread of thickness classes (0.50–0.54, 0.55–0.59, 0.60–0.64 etc.). All fragments were white (or shades close to white) except for six of the 79 fragments in OM AV7477, which were green. Green eggshell belongs to *Megalapteryx didinus* (see Gill, 2007), but the identity of white eggshell is open to conjecture.

Moa faunas. The moa faunas at each site are known from the identity and relative abundance of bones. The taxonomy and nomenclature of moas is still under review. Bunce *et al.* (2003) showed that instead of three species of giant moas *Dinornis* throughout New Zealand there is just one North Island species (*D. novaezealandiae*) and one South Island species (*D. robustus*). This has simplified the moa fauna at most sites. Worthy (2005) showed that the stout-legged moa, previously called *Euryapteryx geranoides*, should now be called *Eu. gravis*, and that Mappin's moa *Pachyornis mappini* is now *P. geranoides*.

It is also likely that *Eu. gravis* (North and South Islands) and *Eu. curtus* (North Island only) are conspecific, with size-differences in the bone samples reflecting various combinations of temporal, geographic and sexual variation (Tennyson & Martinson, 2006: 36, 146; T.H. Worthy, pers. comm. 2008). For example, *Eu. gravis* is recorded from Tokerau Beach but such bones probably belonged to the biggest of the larger (female) individuals of *Euryapteryx* at that site. Worthy (1987) showed that histograms of bone-lengths of *Euryapteryx* from Tokerau Beach were all bimodal, and he considered the different size-classes to reflect sexual dimorphism. The Holocene bones of *Euryapteryx* vary clinally in size, tending larger towards the south (Worthy, 1987). The two nominal species are referred

Table 1. Presumed relative abundance of moa taxa (based on bones) at North Island sites where eggshell thickness was assessed. ••• predominant, •• present, • rare, — absent.

	Euryapteryx	*P. geranoides*	*A. didiformis*	*D. novaezealandiae*
North Cape	•••	••	—	•
Tokerau Beach	•••	•	—	•
Puketitiri	—	••	•••	•
Castle Point	•••	•••	••	••

Table 2. Presumed relative abundance of moa taxa (based on bones) at South Island sites where eggshell thickness was assessed. ••• predominant, •• present, • rare, — absent.

	Euryapteryx	*P. elephantopus*	*A. didiformis*	*E. crassus*	*M. didinus*	*D. robustus*
Wairau Bar	•••	•	•	••	•	•
Oamaru	•••	••	?	••	?	?
Chatto Creek	•••	••	—	••	••	••
Shag River	•••	•	—	••	—	••

to here together as *Eu. "curtus-gravis"*. Tables 1 and 2, and the following notes, summarize the Holocene moa faunas at the sites in this study.

North Cape. The most abundant moas were *Euryapteryx "curtus-gravis"* and *Pachyornis geranoides*, while *Dinornis novaezealandiae* was rarer (Atkinson & Millener, 1991). Evidence from bones is that *P. geranoides* was nearly as common as *Eu. "curtus-gravis"*.

Tokerau Beach. About 95% of skeletons in the area are *Eu. "curtus-gravis"* (Worthy & Holdaway, 2002: 184). Rarer species at the site (evidence discussed by Gill, 2000) were *P. geranoides* and *D. novaezealandiae*.

Puketitiri. *Anomalopteryx didiformis* was the main moa found at caves and rock-shelters of inland Hawke's Bay, closely followed by *P. geranoides*, with *D. novaezealandiae* rarer (Worthy & Holdaway, 2000).

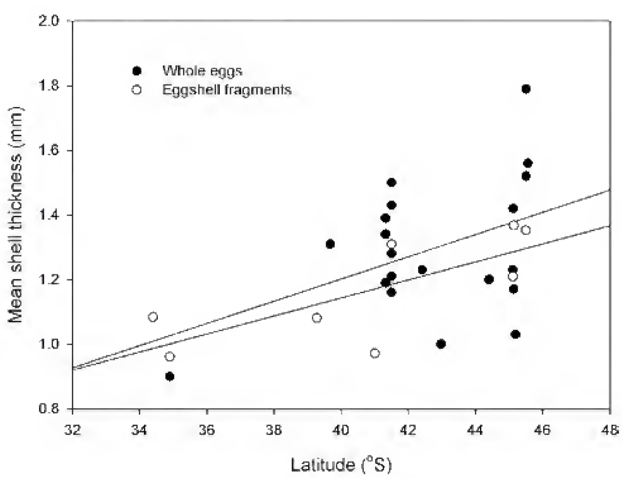


Figure 2. Regressions of mean eggshell thickness on latitude for the eight geographic samples in this study (Table 3) and for the 20 whole moa eggs for which measurements of eggshell thickness are possible (Gill, 2007). For eggshell fragments (open circles), the four North Island data-points are at bottom left and the four South Island ones at middle right. The regression lines and correlation coefficients are: y = 0.028x + 0.027, r = 0.75 (fragments; lower line); y = 0.034x–0.17, r = 0.44 (whole eggs; upper line).

Castle Point. *Pachyornis geranoides* and *Eu. "curtus-gravis"* were co-dominant in the area with lesser numbers of *A. didiformis* and *D. novaezealandiae* (T.H. Worthy, pers. comm. 2008). The moa fauna was therefore very like that at North Cape.

Wairau Bar. *Euryapteryx "curtus-gravis"* predominated with lesser numbers of *Emeus crassus* and rare examples of *A. didiformis, Megalapteryx didinus, Pachyornis elephantopus* and *Dinornis robustus* (Scofield *et al*., 2003).

Oamaru. *Euryapteryx "curtus-gravis"* dominated and *P. elephantopus* was much less common (Worthy & Holdaway, 2002: 181). *Emeus crassus* was present (Trotter, 1970).

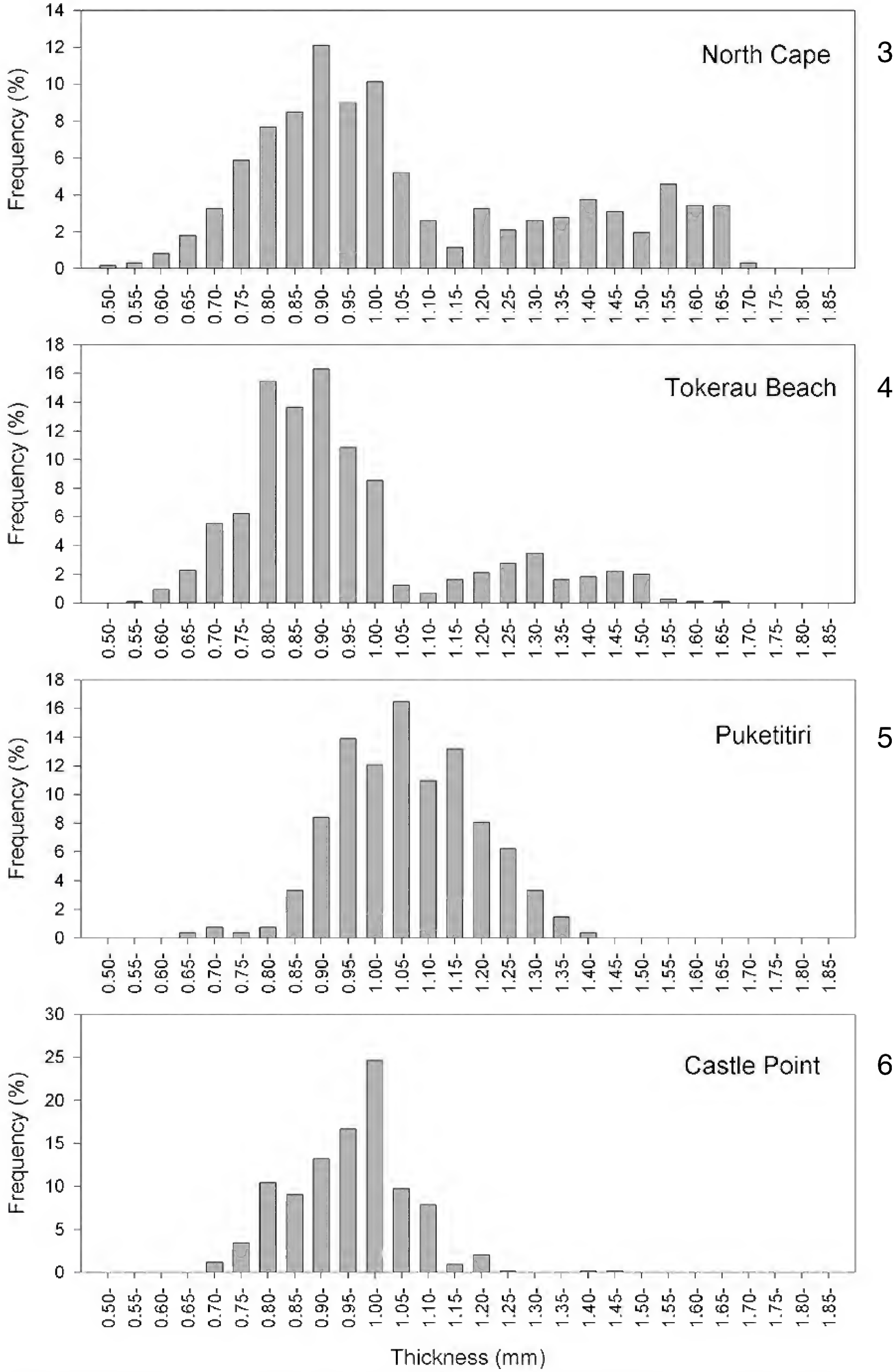
Chatto Creek. In the Central Otago area *Eu. "curtus-gravis"* was the dominant moa, with lesser numbers of *P. elephantopus, Em. crassus, M. didinus* and *D. robustus* (Worthy, 1998).

Shag River. *Euryapteryx "curtus-gravis"* was the dominant moa with lesser numbers of *Em. crassus* and *D. robustus* (Anderson *et al*., 1996).

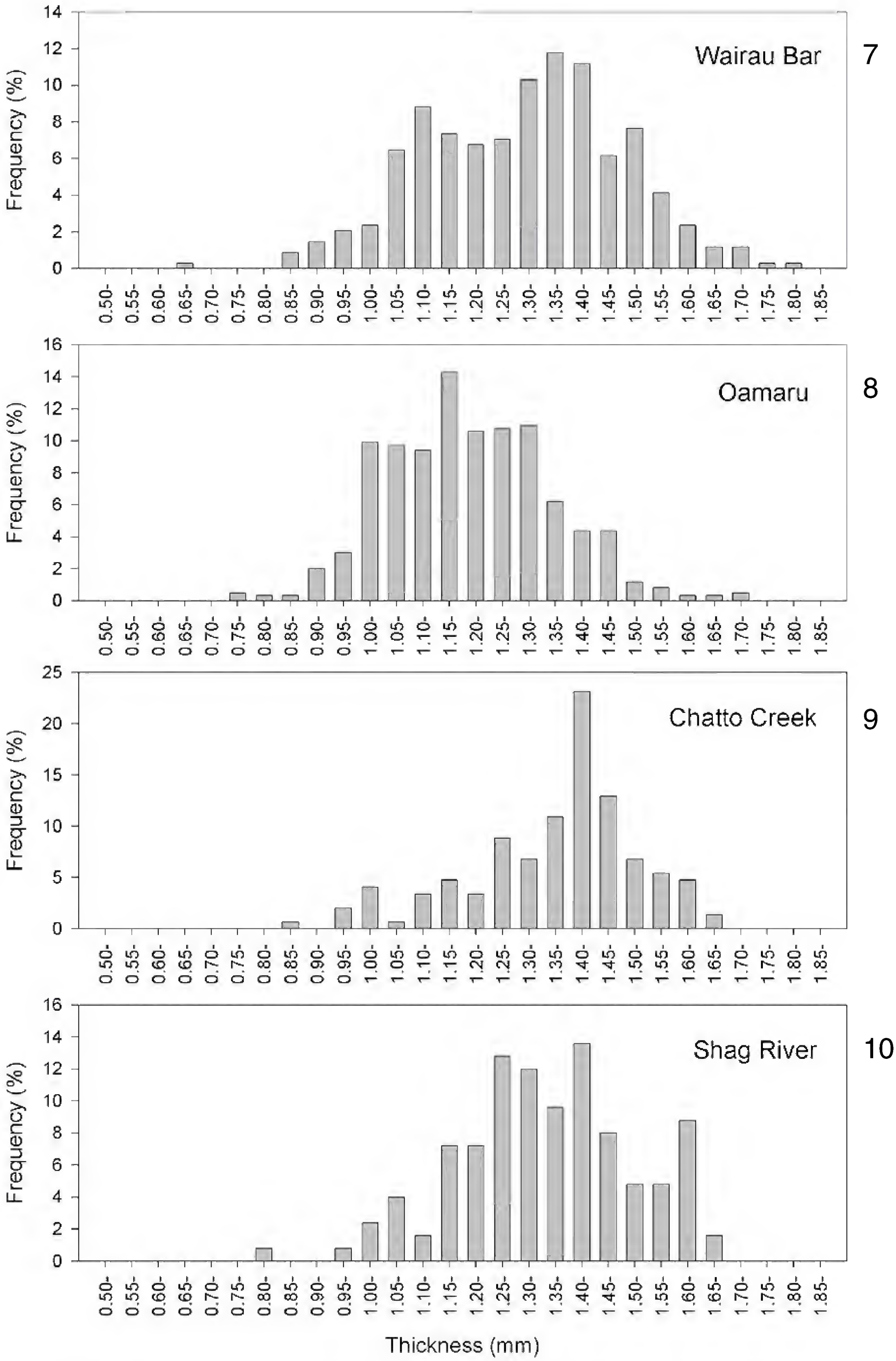
Results

Table 3 summarizes thickness for the samples of eggshell fragments at the eight sites in this study, and for whole moa eggs, and shows that minimum, mean and maximum thicknesses tend to be higher for South Island than for North Island samples. Fig. 2 shows the relationship between mean thickness and latitude for the eight broken eggshell samples (open circles). The eggshell thicknesses of whole eggs (Fig. 2; closed circles) show a very similar regression to the eggshell fragments, though data for the North Island are few.

Figures 3–10 show the histograms of moa eggshell thickness for each of the eight sites. North Cape (Fig. 3) and Tokerau Beach (Fig. 4) show a similar pattern—a broadly bimodal distribution with a spread of numerous thin eggshell fragments (mode at 0.90–0.94 mm) and a second spread of rarer thicker fragments (mostly 1.2–1.7 mm thick). The thin eggshell was presumably produced by *Euryapteryx "curtus-gravis"* with a lesser contribution by *Pachyornis geranoides*. Both are small moas, and the former is particularly small in the north (Worthy, 1987). The latter species would have had a



Figures 3–6. Histograms of moa eggshell thicknesses for samples of (Fig. 3) 612 fragments from North Cape, Northland; (Fig. 4) 1042 fragments from Tokerau Beach, Northland; (Fig. 5) 273 fragments from Puketitiri, Hawke's Bay; and (Fig. 6) 431 fragments from Castle Point, Wairarapa.



Figures 7–10. Histograms of moa eggshell thicknesses for samples of (Fig. 7) 340 fragments from the Wairau Bar archaeological site, Marlborough; (Fig. 8) 595 fragments from the Oamaru archaeological site; (Fig. 9) 147 fragments from Chatto Creek, Central Otago; and (Fig. 10) 125 fragments from the Shag River archaeological site, Otago.

Table 3. Latitude (°S) and descriptive statistics for eggshell thickness (mm) for samples of moa eggshell fragments from eight sites around New Zealand (Fig. 1). In brackets after range is the arithmetic extent of the range (mm), i.e. maximum minus minimum. Maximum and minimum eggshell thicknesses (mm) for the North and South Islands (overall) are shown for the samples of eggshell fragments in this study, and for the whole eggs for which eggshell thicknesses can be measured (Gill, 2007).

locality	mean	n	s.d.	range	latitude
North Island					
North Cape	1.08	612	0.287	0.54–1.71 (1.17)	34.4
Tokerau Beach	0.96	1042	0.210	0.56–1.69 (1.13)	34.9
Puketitiri	1.08	273	0.129	0.65–1.41 (0.76)	39.3
Castle Point	0.97	431	0.109	0.70–1.48 (0.78)	41.0
fragments (overall)				0.54–1.71	
whole eggs				0.90–1.50	
South Island					
Wairau Bar	1.31	340	0.188	0.66–1.82 (1.16)	41.5
Oamaru	1.21	595	0.156	0.77–1.73 (0.96)	45.1
Chatto Creek	1.37	147	0.161	0.89–1.65 (0.76)	45.1
Shag River	1.35	125	0.167	0.83–1.69 (0.86)	45.5
fragments (overall)				0.66–1.82	
whole eggs				1.02–1.89	

minor contribution at Tokerau Beach and a greater contribution at North Cape, according to the relative abundance of bones at these sites, but the eggshells of the two species seem inseparable in the histograms. The thick eggshell at the two northern sites (Figs. 3, 4) was presumably produced by *Dinornis novaezealandiae*, the only large moa present.

Puketitiri (Fig. 5) and Castle Point (Fig. 6) show broadly unimodal thickness histograms of thin to medium-thickness eggshell, with thick eggshell almost absent. At Puketitiri the eggshell is assumed to be mainly from the small species *Anomalopteryx didiformis* and the even smaller *P. geranoides*. At Castle Point the assumption is that the eggshell is a mixed sample attributable largely to *P. geranoides* and *Eu. "curtus-gravis"*, as at North Cape and Tokerau Beach. Indeed, the frequency distribution at Castle Point, with a mode at about 1.0 mm, is very like that of thin eggshell at the two northern-most sites. *Anomalopteryx didiformis* probably had thicker eggshell than *P. geranoides*, being larger, and this may be reflected in the thicker eggshell overall at Puketitiri than at Castle Point. Some of the thickest eggshell at Puketitiri, and the few pieces in the 1.40–1.49 mm range at Castle Point, may belong to *Dinornis*.

The four South Island samples are all broadly unimodal and towards the thicker end of the spectrum. Very thin eggshell is rare. The modal thicknesses at Wairau Bar (Fig. 7), Chatto Creek (Fig. 9) and Shag River (Fig. 10) are all at 1.35–1.44 mm. Oamaru (Fig. 8) has a lower mode (1.15–1.19 mm) but greater modal thickness than for the two North Island unimodal samples (Puketitiri and Castle Point). *Eu. "curtus-gravis"* dominated the bones at all four South Island sites, and much of the eggshell presumably belongs to this moa, which is large-statured in the South Island.

However, the South Island situation is compounded by a greater diversity of moas at each site (usually 4–6 spp.; Table 2) than in the North Island (3–4 spp.; Table 1). *Emeus crassus, Anomalopteryx didiformis* and *Megalapteryx didinus* could have contributed the thinnest eggshells in most of the South Island samples, and *Pachyornis elephantopus* and *Dinornis robustus* were present at most sites to contribute the thickest eggshell fragments.

A few fragments from Chatto Creek (4%) were green, i.e. attributable to *M. didinus*, and all were 0.89–1.13 mm thick, placing them at the very left-hand tail of the histogram (Fig. 9). White eggshell in that thickness range was also present, which at Chatto Creek could be *Megalapteryx* eggshell that has faded to white (see Gill, 2007), or attributable to *E. crassus*.

North Cape and Tokerau Beach have larger ranges of eggshell thicknesses (1.17 mm, 1.13 mm; Table 3) than all other sites except Wairau Bar (1.16 mm; Table 3). However, the thickness range at Wairau is exaggerated by one outlying thin fragment in the 0.65–0.69 mm range (Fig. 7) which could conceivably belong to a large bird other than a moa.

Discussion

The latitudinal trend in moa eggshell thickness, with thicker eggshells in the south (Fig. 2), has two probable explanations. One underlying factor will be the presence of certain large moa species in the South Island (most notably *Pachyornis elephantopus*) that are absent in the North Island. However, Bergmann's Rule may also be involved. For New Zealand birds, this predicts that where a species varies geographically in size, individuals in cooler (e.g., southern) areas will be larger. Bergmann's Rule is thought to have operated in Holocene populations of various moas, e.g., *Euryapteryx* (Worthy, 1987, 1992) and *Dinornis* (Worthy *et al.*, 2005), whose populations are present in both islands. If the birds of these species varied clinally in body-size, then so too may the size of their eggs and the thickness of their eggshells.

In general, the histograms of moa eggshell thickness seem to mirror closely what is known of the diversity and relative abundance of moas at the sites. For example, the bimodally distributed thick and thin eggshell at the two northern-most sites (Figs 3, 4) seem to fit with the indication from bones of numerous small moas (*Euryapteryx "curtus-gravis"* and *Pachyornis geranoides*) and rarer large moas (*Dinornis novaezealandiae*). The extreme spread of eggshell thicknesses at each of the two northernmost sites must reflect the presence there of moas of extreme sizes—the smallest known members

of the *Euryapteryx "curtus-gravis"* complex and a *Dinornis*. The situation is now much simpler and clearer than when three species of *Dinornis* and two of *Euryapteryx* were thought to occur at Tokerau Beach (Gill, 2000).

We can infer from the histograms that both *Euryapteryx "curtus-gravis"* and *Pachyornis geranoides* had eggshell roughly 0.5–1.2 mm thick at North Cape (Fig. 3) and 0.6–1.1 mm at Tokerau Beach (Fig. 4). A whole egg from Tokerau Beach thought to belong to *Eu. "curtus-gravis"* (Gill, 2006: Egg 2) has eggshell about 0.9 mm thick (Archey, 1931), which places it at the mode in both thickness histograms and in the centre of the spread of thin eggshell fragments. The same histograms suggest that the eggshell of *Dinornis novaezealandiae* was approximately 1.1–1.7 mm thick but there is no information from whole eggs on eggshell thickness in this species. The largest North Island egg (Gill, 2006: Egg 5, Waitomo) is probably *Dinornis* but the eggshell fragments are assembled in a way that prevents their thickness being measured. The thickest eggshell measured from North Island whole eggs is only 1.5 mm (Table 3) and was attributed to *Anomalopteryx* (Gill, 2006: Egg 8).

We can predict from Fig. 5 (Puketitiri) that *P. geranoides* had eggshell from about 0.7 mm thick to an unknown maximum, and that *A. didiformis* at the same site had eggshell from an unknown minimum to 1.4 mm thick. No whole eggs of *P. geranoides* are known but four whole eggs from inland North Island sites and most likely attributable to *A. didiformis* have data on eggshell thickness (Gill, 2006, 2007: Eggs 7, 8, 13 and 14). The attribution of the eggs to *Anomalopteryx* is based on that small species dominating at the inland sites where the eggs were found and on the eggs being small (i.e. 152–175 mm long). Thirty-five eggshell thickness measurements from these four eggs had a range of 1.1–1.5 mm. This supports the notion that at least the thicker eggshell at Puketitiri belonged to *A. didiformis*. By elimination, much of the thinner eggshell at Puketitiri, especially in the range 0.7–1.0 mm, must belong to *P. geranoides*. At Castle Point, where the small and similarly-sized *P. geranoides* and *Eu. "curtus-gravis"* dominated (on bone evidence), most of the eggshell was indeed in that range (Fig. 6).

Given that the large South Island form of *Eu. "curtus-gravis"* dominated the bones at all four South Island sites, the frequency bars in the histograms suggest that its eggshell was about 1.1–1.5 mm thick at Wairau Bar (Fig. 7), 1.0–1.3 mm at Oamaru (Fig. 8), 1.3–1.5 mm at Chatto Creek (Fig. 9) and 1.2–1.6 mm at Shag River (Fig. 10), or roughly 1.0–1.6 mm for the South Island in general. Considering whole eggs, there are seven South Island eggs possibly attributable to *Euryapteryx* (Gill, 2006, 2007): Eggs 16 and 18–21 from the same Wairau Bar site as the eggshell fragments (Fig. 7) and Eggs 11 and 32 from the same Oamaru site as in Fig. 8. These eggs are not objectively linked to *Euryapteryx*, but they are medium-sized (i.e. 194–215 mm long) and assumed to belong to the medium-sized moa that dominates bones at the sites. Fifty-three thickness measurements from these seven eggs had a range of 1.1–1.7 mm. This close agreement in thickness between the broken eggshell and whole eggshells reinforces the conjecture that the bulk of the eggshell fragments at Wairau Bar, Oamaru, Chatto Creek and Shag River are from medium-sized eggs that were probably *Euryapteryx*.

Green eggshell fragments at Chatto Creek were thin (0.89–1.13 mm) and signal the presence of *Megalapteryx didinus*. Three whole green eggs, two from Chatto Creek (Gill, 2006: Eggs 22 and 23) and one from Mt Aspiring National Park (Egg 29), had similarly thin eggshell (1.1–1.2 mm thick; Gill, 2007). A whole egg from the Shag River site has an eggshell-thickness of 1.73–1.89 mm (Gill, 2007: Egg 27), the thickest moa eggshell ever recorded, and thought to belong to *P. elephantopus*. This extreme thickness was not represented in the broken eggshell sample from that site (Fig. 10); the sample of 125 fragments was clearly not large enough. However, the Shag River sample has a big peak at 1.60–1.64 mm, more so than for any other sample. These thickest fragments in the Shag River sample may be attributable to *P. elephantopus*.

The archaeological eggshell samples at Wairau Bar, Oamaru and Shag River are presumably biased towards the moa eggs that local Maoris collected and discarded. Yet the range of eggshell thicknesses at these midden sites is very large, and seems no different from the range of thicknesses at natural sites (Table 3). This suggests that moa eggs of all available sizes (i.e. from all available species) were collected for human use, not just the largest ones.

This study suggests a usefulness in histograms of moa eggshell thicknesses generated for specific paleontological and archaeological sites. Moa eggshell thickness profiles seem broadly to reflect the moa faunas at the sites, and may be a helpful adjunct to, or surrogate for, information on the relative abundance of moa bones at sites. This is especially so in the North Island where moas are usually less diverse at a site than in the South Island.

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Appendix

Museum registration numbers of the samples from which moa eggshell fragments were measured for thickness (number of fragments measured shown in brackets). Where the number measured was not the entire sample, fragments were chosen at random. Museum codes: *UO*, Anthropology Department, University of Otago, Dunedin; *AIM*, Auckland Museum, Auckland; *CMC*, Canterbury Museum, Christchurch; *HBM*, Hawke's Bay Museum, Napier; *NMNZ*, Museum of New Zealand Te Papa Tongarewa, Wellington; *OM*, Otago Museum, Dunedin.

North Cape (24 samples, 612 fragments). Samples collected 1976–1999 by F.J. Brook, N. Douglas, B.J. Gill, R. Renwick and H. Seelye.—*Tom Bowling Bay* (22 samples, 591 fragments). AIM LB6774 (1), LB6775 (7), LB7930 (81), LB7931 (39), LB7932 (27), LB7933 (16), LB7934 (16), LB7935 (31), LB7937 (30), LB8487 (23), LB8488 (4), LB8510 (65), LB8511 (4), LB8862 (5), LB8863 (29), LB9223 (8), LB9224 (1), LB9226 (27), LB9227 (37), LB9228 (34), LB9230 (39), LB9231 (67).—*Waikuku Beach* (2 samples, 21 fragments) AIM LB7936 (18), LB8825 (3).

Tokerau Beach (97 samples, 1,042 fragments). See Gill (2000: Appendix 1).

Puketitiri (5 samples, 273 fragments). Samples collected 1950s to 1961 by W.H. Hartree and J.C. Yaldwyn. In separate labelled containers at HBM; not registered or numbered. "Bush Face No. 1" (140), "Hukanui No. 7b 1959–1960" (25), "Hukanui No. 7b May 1960" (40), Hukanui No. 7b (cigarette tin) (60), Hukanui No. 7b (another cigarette tin) (8).

Castle Point (11 samples, 431 fragments). Samples collected 1934–2000 by E. Barton, T. Cairns, I. Cameron, I. Dandermam, E. Smith and A.J.D. Tennyson.—*Coast between Mataikona and Whakataki* NMNZ S23166 (52), S23167 (15), S36733 (3), S37890 (20), S37910 (13), S37913 (92), S37923 (23), S38403 (97), S38441 (56), S38460 (10), S40676 (50).

Wairau Bar (23 samples, 340 fragments). Archaeological excavations by J.R. Eyles, R. Duff, R. Perano and Canterbury Museum Archaeological Society 1942–1959. CMC AV19947 (4), AV19948 (50), AV19951 (20), AV19960 (25), AV19966 (27), AV19968 (7), AV19971 (22), AV19974 (10), AV19978 (13), AV19979 (12), AV19981 (16), AV19986 (6), AV19987 (35), AV19990 (6), AV20038 (8), AV21128 (27), AV21129 (10), AV21137 (5), AV21167 (28), AV25620 (1), AV25882 (1), AV29513 (4), AV29528 (3).

Oamaru (23 samples, 595 fragments). Archaeological excavations by W.B.D. Mantell ca. 1852.

The Mantell collection at AIM (LB4014) is a large assemblage of eggshell fragments believed to have been collected from a Maori midden site at Awamoa, near Oamaru, North Otago (Archey, 1941: 74). Mantell grouped the fragments on some basis. Within each group, numerous fragments are joined in an attempt to reconstruct sections of the original eggs, but thickness varies greatly within most of these groupings so they cannot represent separate individual eggs.

Boxes A–D (20), Box E (1), Boxes F–G (2), Box H (56), Box I (23), Boxes J-K (20), Box L (17), Boxes M-N (23), Box O (21), Box P (17), Box Q (20), Box R (30), Box S (27), Box 4014/1 (56), Box 4014/2 (43), Box 4014/3 (92), Box 4014/4 (22).

Chatto Creek (2 samples, 147 fragments). Samples collected ca. 1954 (collector not recorded). OM AV7376 (68), AV7477 (79).

Shag River (2 samples, 125 fragments). Archaeological excavations led by A. Anderson 1988–1989. UO SM/B (23), SM/C (102).